



Arrow Vision Series

Power Management



Circuit Protection Gone WILD!

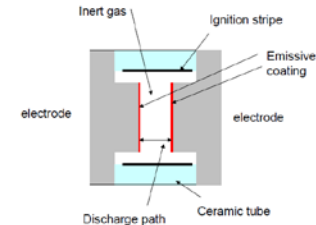
Introduction

- Selecting the appropriate circuit protection component is critical to a safe and robust design
- Sometimes, selecting the incorrect component can lead to catastrophic failures
- This presentation will show examples of proper and improper device selection and the consequences

Glowing Reviews of the (Wrong) GDT

■ Background:

- Selecting the appropriate GDT for power line applications
 - Surge protection on AC or DC power lines is typically done by using MOVs
 - GDTs are typically used in signal applications or one N – PE leg due to minimal available currents



■ Problem:

- Upon seeing overvoltage surge, GDTs will break-over (crow-bar) by creating a sustained arc across the electrodes; surge current then shunted to ground, usually.
- When surge event subsides, the GDT arc will be extinguished and system will return to normal
- If power is applied to the line, the “follow current” will sustain the arc and the GDT may not be able to turn off.
- GDT will then thermally fail due to sustained currents (glow red hot)

■ Solution:

- Littelfuse has AC power optimized GDTs (AC120/240 Series)

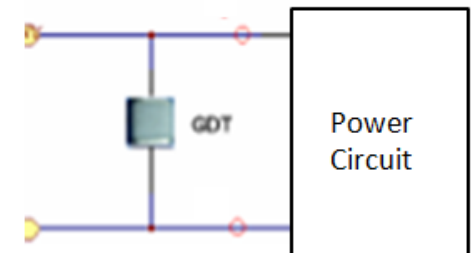
Glowing Reviews of the (Wrong) GDT

■ Test Set-up:

- 120V tube, AC coupled, 6KV/3KA, limited to 10A follow thru current
- Littelfuse AC120 GDT (designed for power lines)
- Littelfuse SL series GDT (designed for signal apps)

■ Video:

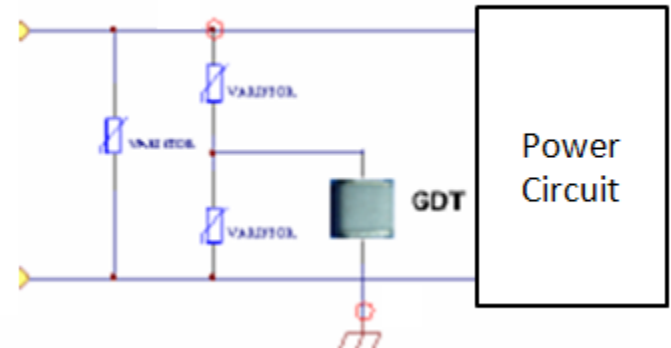
- 1. Littelfuse AC120 (GOOD) - [LINK](#)
- 2. Littelfuse SL series (BAD) - [LINK](#)



Glowing Reviews of the (Wrong) GDT

■ Additional Information:

- MOVs can be placed in series with GDTs
- MOV will help cut off the follow current and allow GDT to turn off
- During surge event, MOV will clamp and conduct first into a low impedance state ; then GDT will break-over and create the arc.
- When surge subsides, the MOV will go back to high impedance state and will quench the follow current and allow GDT arc to be extinguished



MOV End of Life Failures are Really HOT!



■ Background:

- MOV (Metal Oxide Varistors) can degrade over lifetime due to surge events
- MOV material can weaken due to multiple surges and develop “memory” path
- MOV at end-of-life will start to leak current with nominal system voltage applied

■ Problem:

- Leakage will heat up the MOV and impedance will continue to drop leading to thermal run-away failure
- MOV protection solutions needing to meet UL1449 3rd Ed which includes Abnormal Overvoltage testing which simulates this fault condition

■ Solution:

- Select Littelfuse TMOV series products to control MOV end-of-life (EOL) conditions.
- TMOV™ MOVs have integrated thermal protector built inside the disc which will open upon thermal heating of MOV.
- Use of TMOV will prevent catastrophic failure of MOV disc during EOL condition
- TMOVs will help equipment makers pass UL1449 Abnormal Overvoltage Limited Current test requirements without the need for external fuse



MOV End of Life Failures are Really HOT!

■ Test Set-up:

- 150V MOV with 240V/10A fault, AC coupled – simulating EOL condition
- Side-by-side testing 150V TMOV (thermally protected MOV)

■ Video:

- Competitor MOV (Left) ; Littelfuse MOV (Middle) ; Littelfuse TMOV (Right)
- LINK

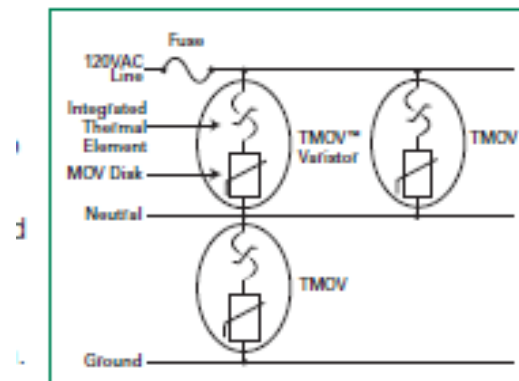


Figure 4. TMOV varistor offline protection scheme



Don't Let Your Diode Die an Untimely Death

■ Background:

- TVS diodes can be used for AC or DC input power protection
- Caution to stay under the surge rating of the TVS diode
- While TVS diodes offer fast and efficient clamping capability, they have limited surge robustness
- IEC61000-4-5 and C.62.41-2002 are popular surge immunity standards
- Maximum indoor surge condition typically is 6kV/3kA, 8/20us surge combo wave

■ Problem:

- TVS diodes can undergo catastrophic failure if over stressed beyond surge ratings
- Traces need to be sized according or will open up as well

■ Solution:

- Select the correct TVS diode surge rating for your application



Don't Let Your Diode Die an Untimely Death

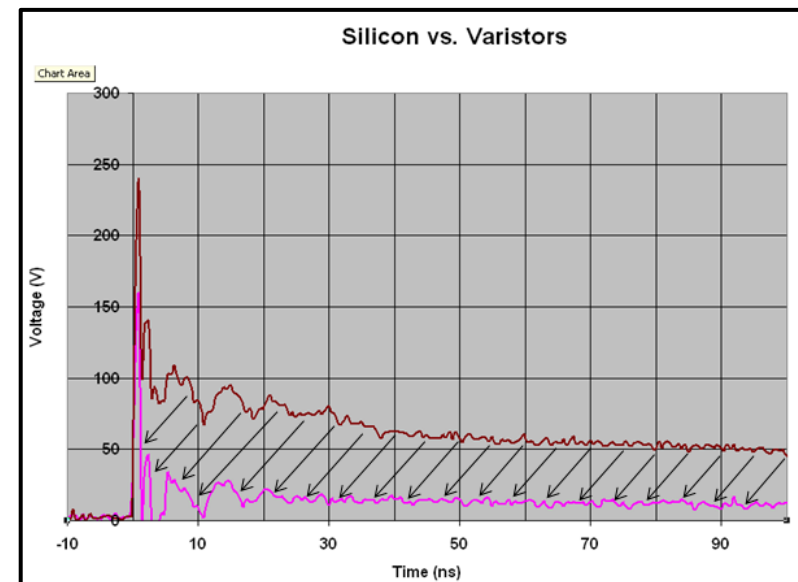
- **Test Set-up:**
 - SMCJ TVS diode, 1500W diode, bidirectional – 6kV/3kAa surge applied
- **Video:** [LINK](#)



Don't Let Your Diode Die an Untimely Death

■ Additional Information:

- Diodes should be selected for a given application by their:
 - Power Rating,
 - Maximum surge current,
 - Standoff Voltage, and
 - Breakdown Voltage
- Though sometimes not as robust as a MOV, a TVS Diode will have the lowest dynamic resistance (the resistance between the threat and ground); therefore, a TVS Diode will clamp better and reduce the overall amount of energy seen by the sensitive electronics downstream.
- The area between the curves represents the amount of energy that DOES NOT get to the chip when an MLV was replaced by an equivalent TVS Diode.



SUNDAY, SUNDAY!! Ethernet Vs. Power Cross

■ Background:

- Ethernet ports needing to meet GR-1089 Inter-Building Power Cross requirements need appropriate overcurrent protection
- Typically, protection is a surge tolerant fuse that will open fast enough during Power cross testing

■ Problem:

- Prevent SEP SIDACtor (overvoltage protector) from getting damaged during power cross testing
- Proper fusing required to comply with GR-1089 Power cross and prevent equipment damage/safety hazard

■ Solution:

- Use Littelfuse 461 Series Telelink fuse (typically 1.25A rating) at port input on cable side
- Use low capacitance, C or D Rated, SIDACtor overvoltage protector (Littelfuse SEP series)



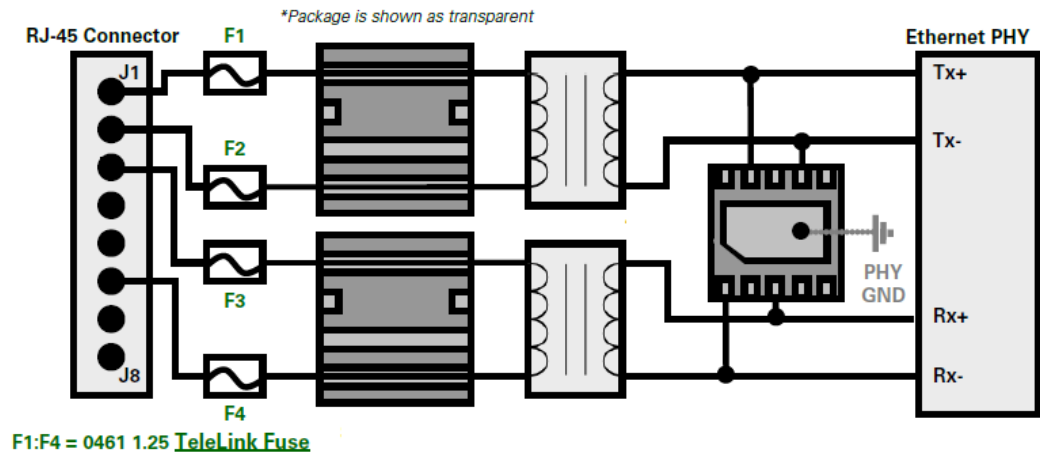
SUNDAY, SUNDAY!! Ethernet Vs. Power Cross

■ Test Set-up:

- Littelfuse Ethernet demo board - Power cross 425V/40A GR-1089 fault – with and without fuse protection
- SEP Series Ethernet surge protector on cable side
- Fuse – Littelfuse 461 series, 1.25A Telelink fuse

■ Video:

- LINK (with fuse)
- LINK (without fuse)



“Fuse Interrupted” (the exploding DVD version)

■ Background:

- Fuse max voltage and max interrupt rating are safety critical specifications
- When fuse opens during fault, the higher voltage applied will cause arc to form longer duration
- Higher voltage and higher current faults will cause plasma formation and molten metal
- Fuse body, fillers, and fuse element designed to quench arc and safely open fuse

■ Problem:

- Deviating from fuse max specs and over-stressing the device will cause catastrophic failures

■ Solution:

- Stay under the fuse voltage and interrupt ratings



“Fuse Interrupted” (the exploding DVD version)

■ Test Set-up:

- Littelfuse 215 series, 5x20mm ceramic fuse ; 3.15A rating ; 250VAC/1500A Interrupt rating
- We applied 250VAC/1500A short circuit fault
- We applied 400VDC, 200A short circuit fault (above fuse voltage rating)

■ Video:

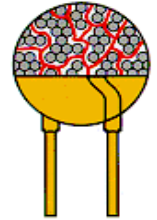
- LINK (within fuse voltage rating)
- LINK (above fuse voltage rating)



The Non-Resettable Resettable Fuse

■ Background:

- Just like fuses, PTC Resettable fuses can experience overvoltage stress and fail
- PTC's most dangerous failure mode is overvoltage stress
- The higher voltage causes damage to the polymer material and will damage the conductive carbon particles



■ Problem:

- Choosing wrong voltage rating can lead to catastrophic failure mode

■ Solution:

- Stay under the max voltage rating of your PTC



The Non-Resettable Resettable Fuse

■ Test Set-up:

- Littelfuse 16R series PTC Resettable fuse being used in 60VDC short circuit fault
- 16R series has max voltage rating of 16VDC
- Littelfuse 60R or 72R series is recommended for this application.

■ Video:

- [LINK](#)



Fusible Resistors are Irresistible (Buyer BEWARE!)

■ **Background:**

- Fusible resistors are poor alternatives to using a properly specified fuse.
- These fusible resistors are frequently used in LED bulb or charger applications due to their low cost.
- FusR will tend to get very hot during overload and burn open causing potential safety hazard.
- Smoke will be generated from burning fusible resistor which is a customer satisfaction issue.

■ **Problem:**

- Unlike a fuse which is designed to open safely during overload condition, a fusible resistor (FusR) will not have a controlled and consistent opening mode.

■ **Solution:**

- Select a Littelfuse fuse designed to meet the specified requirements.

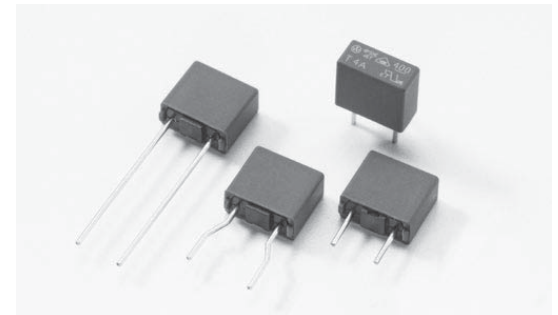
Fusible Resistors are Irresistible (Buyer BEWARE!)

■ Test Set-up:

- Fusible resistor vs. fuse during overload condition
- 392 series TE fuse vs. 10ohm FusR
- 240vac, 200% Overload over the fuse rating

■ Video:

- LINK (392 series fuse – GOOD)
- LINK (10ohm Fusible resistor – BAD)



SMOV – The Superhero of MOVs

■ Background:

- UL1449 3rd Ed, Abnormal Overvoltage Intermediate current testing requires up to 150A fault current when testing MOVs
- Intermediate current testing required for Type 3 SPDs and above.

■ Problem:

- Passing the UL1449 Intermediate current test standards typically requires an external fuse
- Fuse will open before MOVs fail but difficult to select due to 6kv/3ka high surge withstand requirements
- Integrated thermal protection inside Littelfuse TMOV is limited to max 10A fault current

■ Solution:

- Select Littelfuse SMOV Series instead of TMOV to pass UL1449 Intermediate current requirements



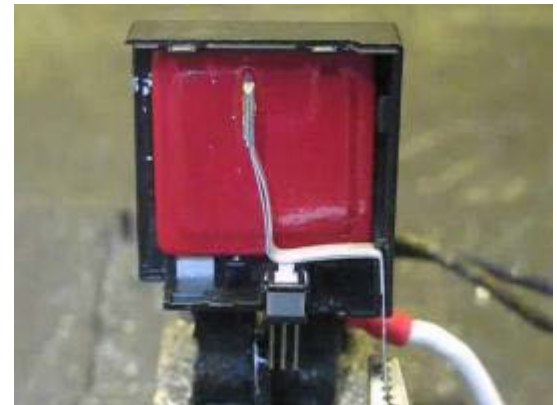
SMOV – The Superhero of MOVs

■ Test Set-up:

- 150V TMOV and SMOV tested at 240VAC/150A Intermediate current per UL1449

■ Video:

- LINK (TMOV failing at 150A – BAD)
- LINK (SMOV opening safely at 150A – GOOD)



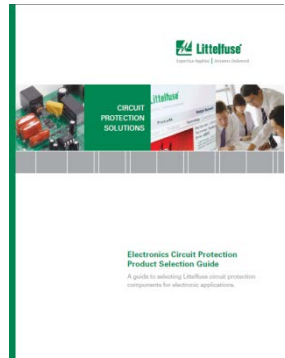
Additional Literature

Additional Literature

Design and Selection Guides

■ Electronic Products Selection Guide

- Available on the Littelfuse website
- Includes all Littelfuse technologies
- Quick reference for all product specifications and applications



■ System Level Design Guide

- Available on the Littelfuse website
- Discusses multiple applications such as:
 - USB1.1/2.0/3.0
 - HDMI/DVI
 - 10/100/1000 Ethernet
 - eSATA
 - Audio (Speaker/Microphone)
 - Keypad/Push button
 - And many more...



■ Ethernet Design Guide

- Includes both TVS Diode Arrays, SIDACtor Devices, and TVS Diodes (for PoE)



Additional Literature

Sample Kits

■ TVS Diode Arrays

- Contains over 55 products and includes all 2012 new product releases



■ TVS Diodes

- Axial Lead 400-1500W
 - SA5.0A, SA12CA, SAC5.0, P6KE27CA, P6KE200A, 1.5KE91A, 1.5KE440A, LEC28A
- Surface Mount 400-1500W
 - SMAJ5.0A, SMAJ58A, P4SMA20CA, P4SMA200CA, SMBJ15A, SMBJ33CA, P6SMB36A, P6SMB200CA, 1KSMB47CA, 1KSMB160A, SMCJ24CA, SMCJ64A, 1.5SMC6.8A, 1.5SMC550CA



Expertise Applied | Answers Delivered

PROTECT | CONTROL | SENSE



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Additional Literature

Miscellaneous

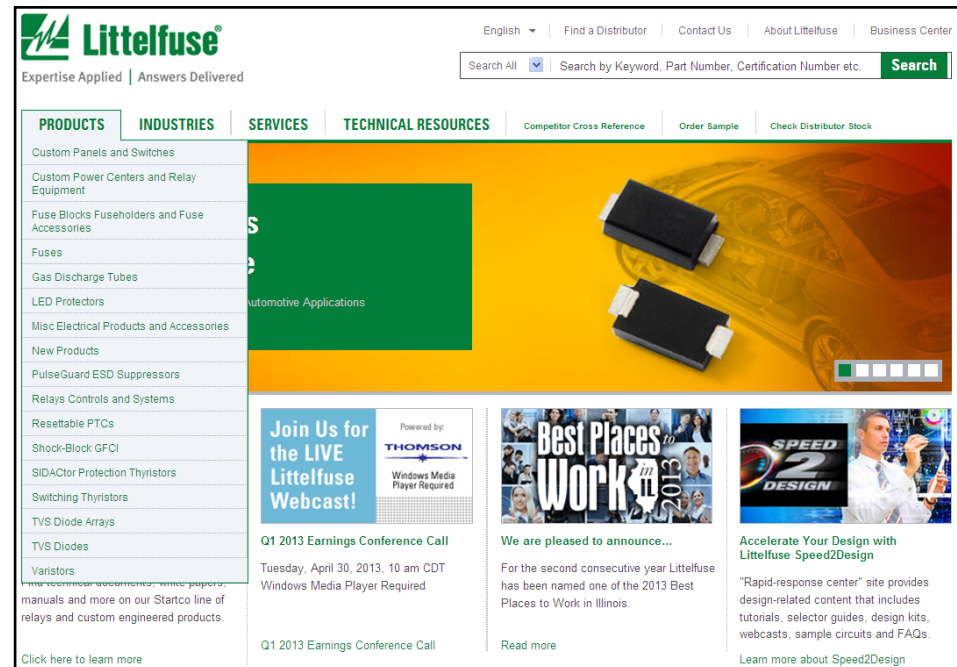
■ TVS Diode Array App

- Only for the iPhone/iPad
- Help in finding the right product for your application



■ Product Catalogs

- Found on Littelfuse.com
- Catalogs are available under the respective product category



Expertise Applied | Answers Delivered

PROTECT | CONTROL | SENSE



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